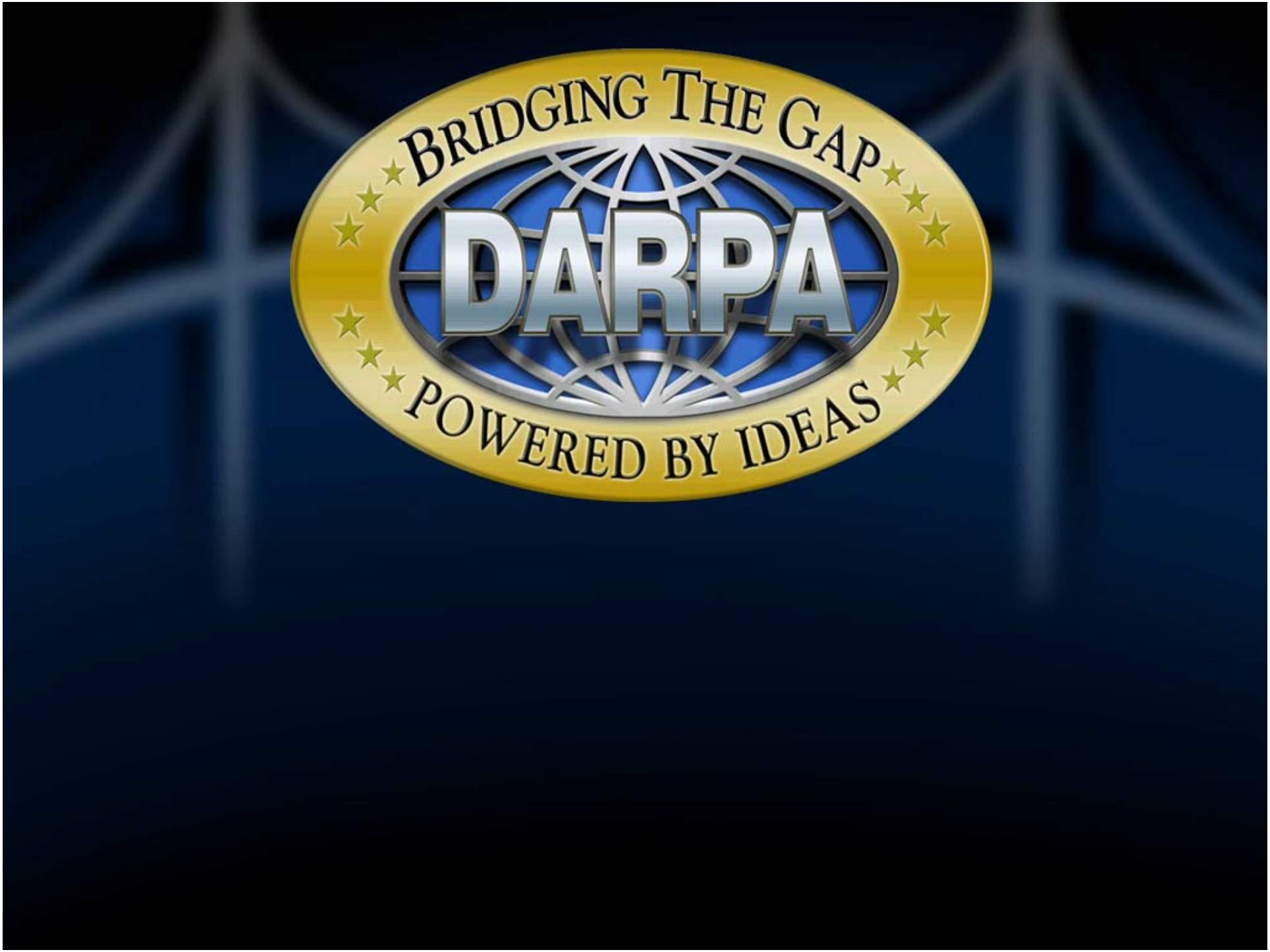
BRIDGING THE GAP
DARPA
POWERED BY IDEAS

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
JUN 2009		**00-00-2009 to 00-00-2009**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
DARPA Bridging the Gap Powered by Ideas	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Defense Advanced Research Projects Agency,3701 N Fairfax Dr,Arlington,VA,22203**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM202744. Presented at the European Command and African Command Science and Technology Conference held in Stuttgart, Germany on 8-12 Jun 2009

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**37**	

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Who/What is DARPA?

The Advanced Research Projects Agency (ARPA) – which came to be known as DARPA in 1972 when its name changed to the Defense Advanced Research Projects Agency – emerged in 1958 as part of a broad reaction to a singular event – the launching by the Soviet Union of the Sputnik satellite on Oct. 4, 1957.

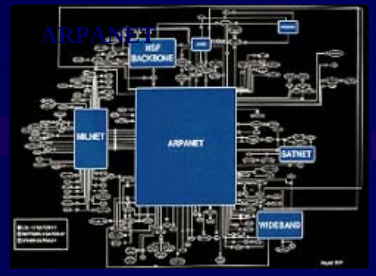
60's

70's

80's

90's

00's

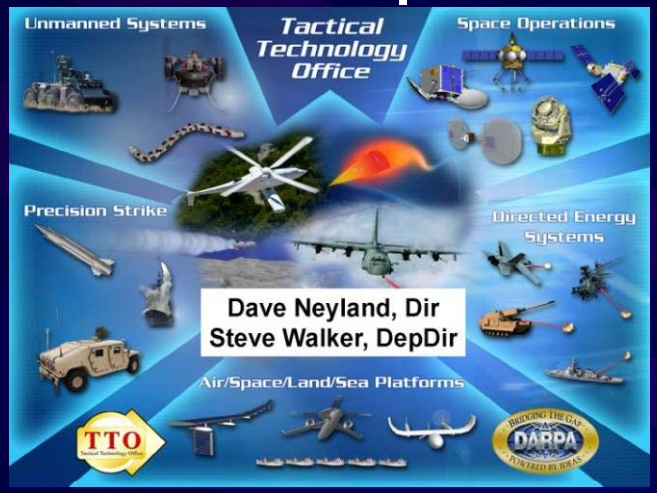


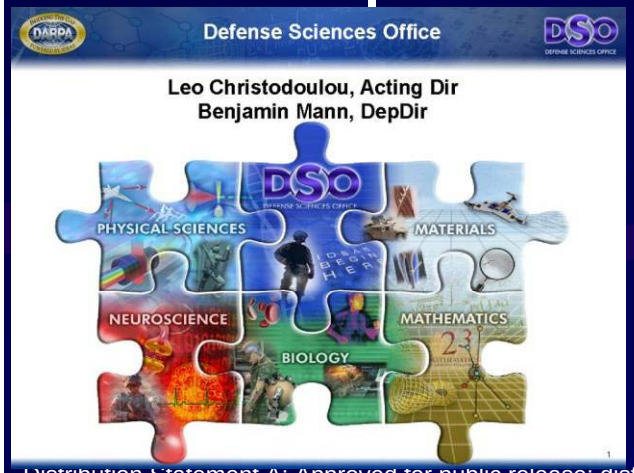
DARPA at a glance

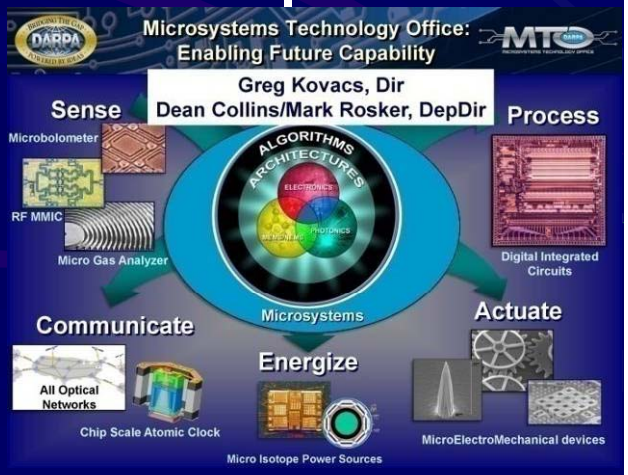
- DARPA's Mission
  - Prevent technological surprise for the United States and to create technological surprise for our adversaries.
- DARPA's Charter
  - Radical innovation
  - Solving hard technical problems
  - Revolutionary capabilities for national security

DARPA Technical Offices

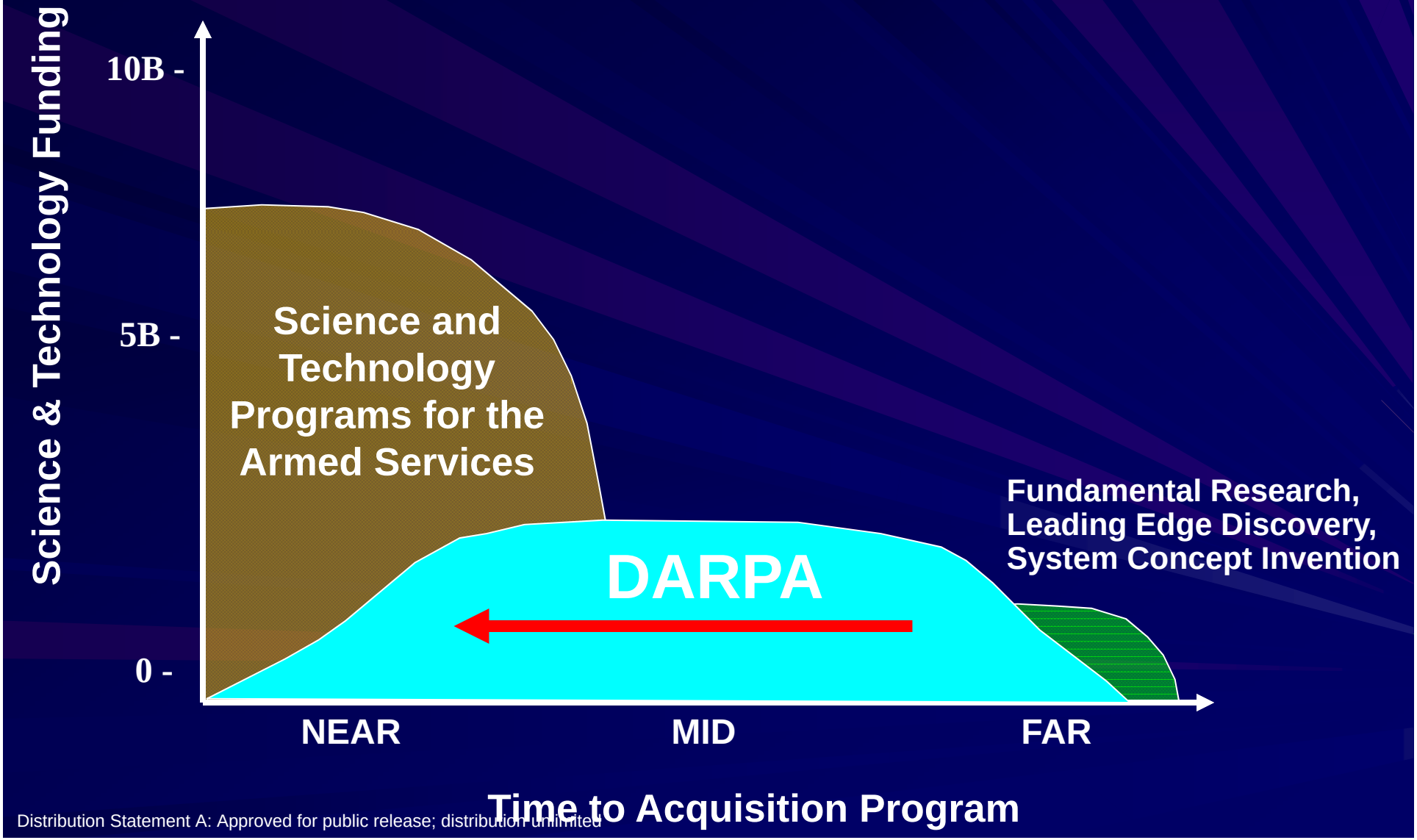
Acting Director, Bob Leheny







DARPA Role in Science and Technology



DARPA's Strategic Thrusts

Investments Today for Future Capabilities

- Robust, Secure, Self-Forming Networks
- Detection, Precision ID, Tracking, & Destruction of Elusive Targets
- Urban Area Operations
- Advanced Manned & Unmanned Systems
- Detection, Characterization, & Assessment of Underground Structures
- Space
- Increasing the Tooth to Tail Ratio
- Bio-Revolution
- Core Technologies (Materials/Electronics/Information Technology)

References for DARPA Projects

Secretary of Defense

Quadrennial Defense Review

Strategic Planning Guidance 2008 – 2013

Combatant Commanders Integrated Priority Lists

USSOCOM CONPLAN 7500-02 – Global War on Terrorism

Joint Program Decision Memorandums

Meetings and Briefs throughout DoD

Operational Liaisons – Transition Agents

Special Assistant / Tech Transition

- **Mr. Chris Earl**

Liaison to Special Operations Command

- **Ms. Kathy MacDonald**

Operational Liaisons

- Col TC Moore, USMC
- COL Valerie Jacocks, USA
- CAPT John Murphy, USN
- Col Will Reese, USAF
- Mr. Fred Schnarre, NGA

Rapid Reaction Support

Bar Armor - Counter RPG

Boomerang

WASP

Tactical Iraqi Language Training

Command Post of the Future

Hand-Held Translator

Broadcast Translation

Cooling Glove

Sniper Rifle

Water Disinfection Pen

TIGR

Current DARPA Programs

That support EUCOM/AFRICOM needs

- Operating in GPS-denied environment
  - Chip-Scale Atomic Clock (CSAC)
  - Robust Surface Navigation/Sub Surface Navigation (RSN/SSN)
  - Micro Inertial Navigation Technology (MINT)
- Long endurance, persistent surveillance
  - Integrated Sensor is the Structure (ISIS)
- Networking/SA for Distributed Operations
  - UltraVis

Current DARPA Programs

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- Operating in GPS-denied environment
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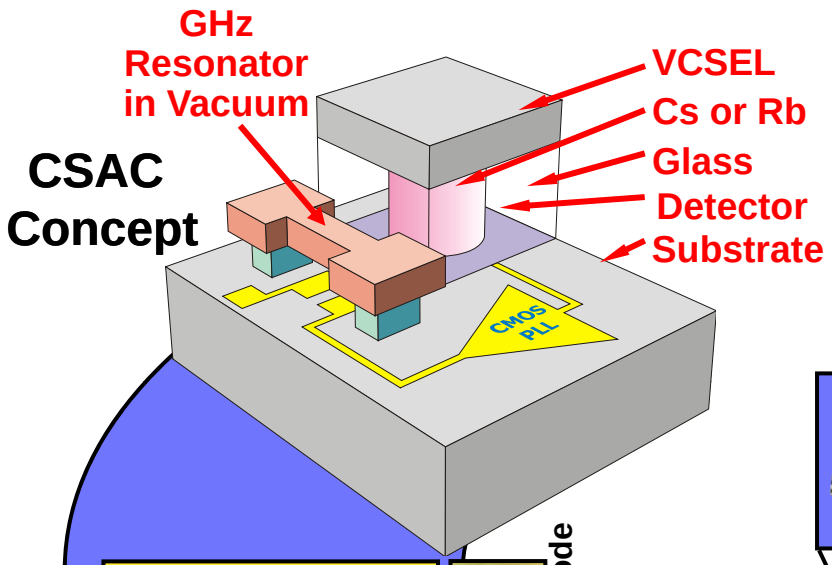
  - Micro Inertial Navigation Technology (MINT)

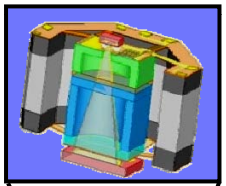
Integrated Microsystem: Chip Scale Atomic Clock



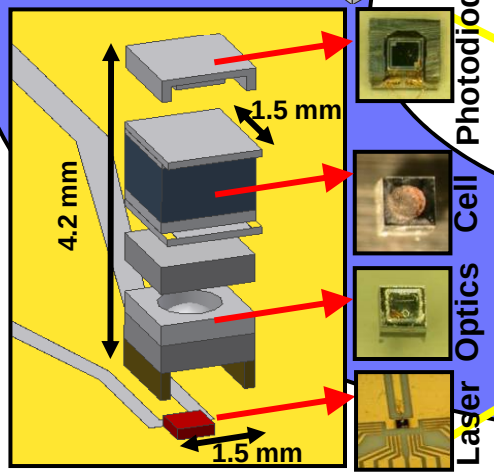
CSAC Concept

Example of Use: Radio System (SINCGARS)

Clock accuracy of 1s/10,000 yrs ⇒
16-hour re-synch interval or radio silence



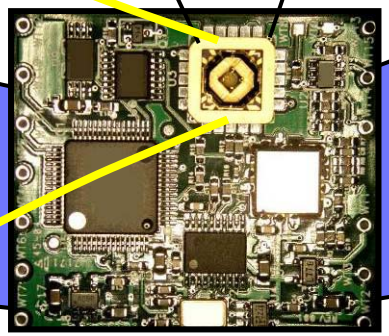
Goal: Vol: 1 cm³
Power: 30 mW
Stab: 1s in 10k yrs



Physics Package

3.94 cm

3.5 cm



CSAC Breadboard

7.8 cm³, 95 mW,
5x10⁻¹¹ at 100 sec

Phase II CSAC Prototype

Precision Time for Every Radio and Network Node

SMU2

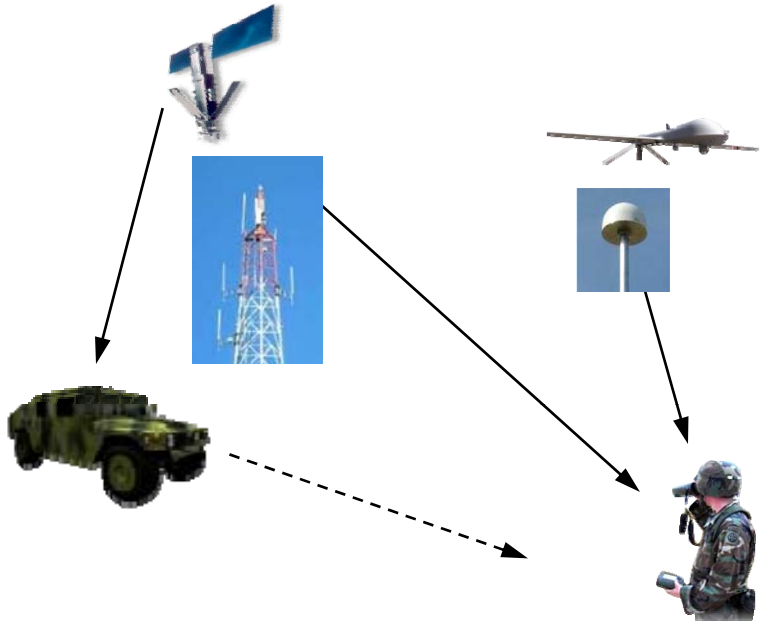
Robust Surface Navigation (RSN)

Why RSN?

- GPS does not work well indoors or in urban canyons
- GPS can be jammed
- Multiple path propagation corrupts positioning accuracy

Goals

- GPS-equivalent capability in GPS-denied environments
- Navigation using signals-of-opportunity
  - Space and terrestrial communications, broadcast, and navigational signaling systems
- Development of beacons for improved versatility when SoOP are limited or non-existent
- Seamless adaptation of receiver to any available signals (GPS, Beacons, or SoOP)



Technical Challenges

- Mitigation and/or exploitation of multipath
- Ability to operate when line-of-sight (LOS) propagation is not available
- Characterization of and synchronization with available SoOP/beacons

RSN Provides Robust Geolocation and Navigation in GPS-Denied Environments

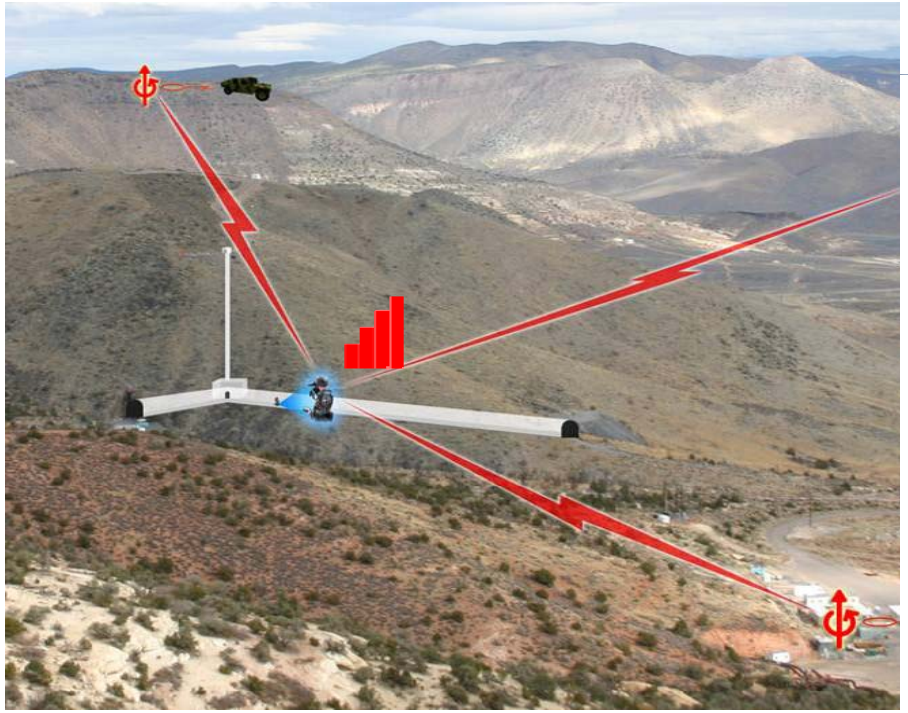
SMU2 Slides 12 & 13 DISTAR case # 10389

Stephen M Urban, 5/26/2009

Sub-Surface Navigation (SsN)

Program Objectives

- Provide the U.S. war fighter with the ability to geo-locate and navigate in environments below the surface of the Earth, where GPS is not available.



Goals

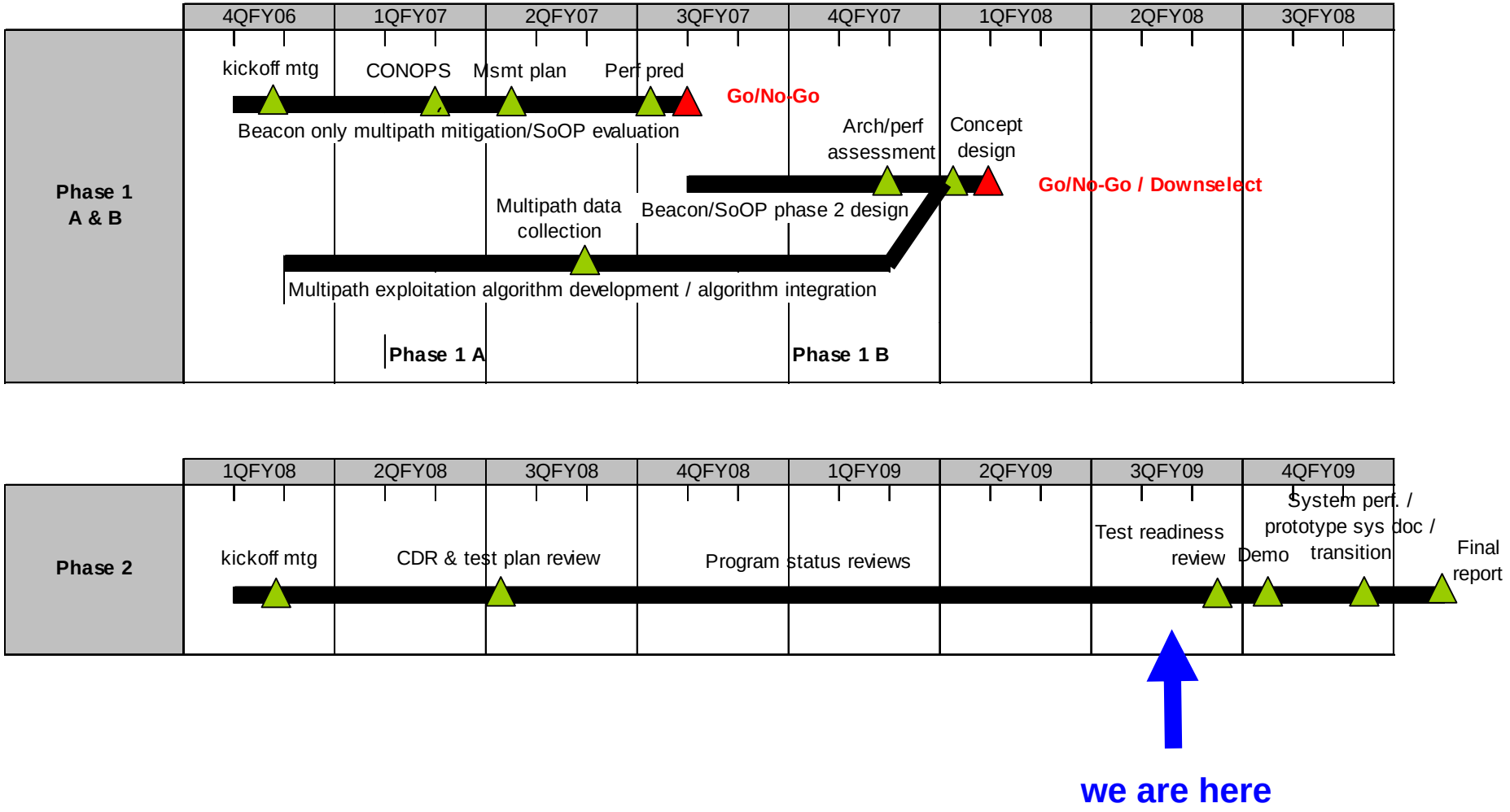
- Provide navigation capability in underground environment, where GPS is not available
- Evaluate the use of signals-of-opportunity (SoOP) for navigation
- Develop beacons for improved versatility when SoOP are limited or non-existent

Technical Challenges

- Signal penetration into underground environment limits operational range
- Signal distortion through non-homogeneous ground limits accuracy and robustness
- Seamless operation above- and below-ground requires additional complexity
- Development of readily deployable receivers and through-the-earth transmitters that do not burden the warfighter

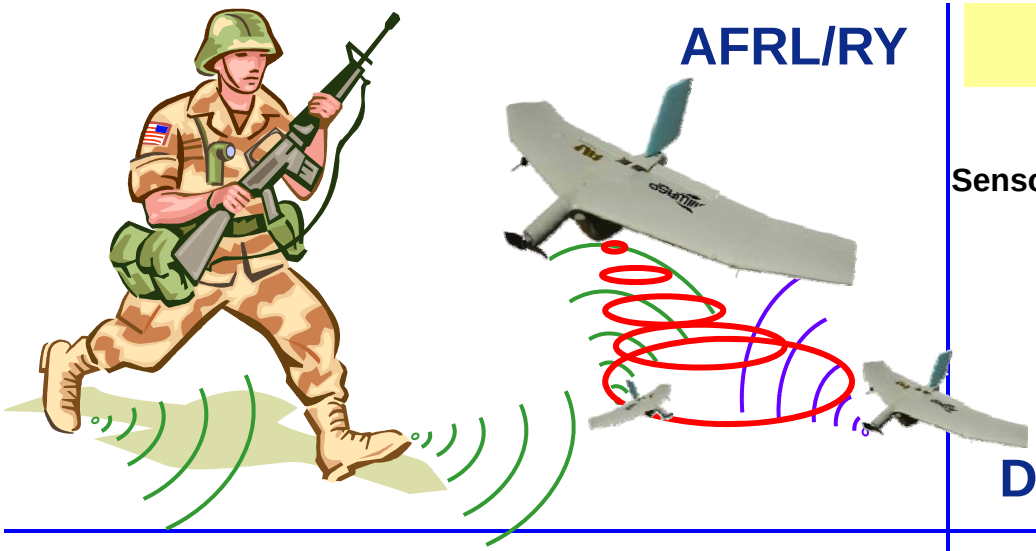
Seamless Underground Navigation and Geo-Location for the War Fighter

RSN Schedule



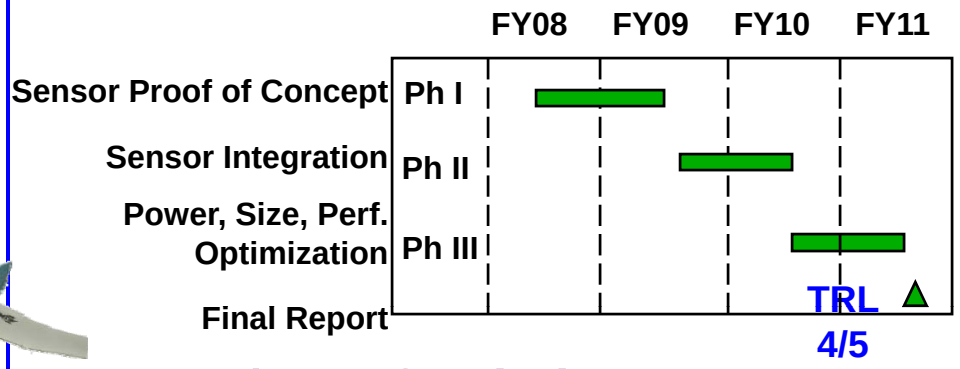
SMU1

Micro Inertial Navigation Technology (MINT)



AFRL/RY

Carnegie Mellon University



DARPA/MTO funded

As of 2 Apr 09

OBJECTIVES/PAYOFF

- **Enable long term (hours to days) GPS denied precise navigation for dismounted soldiers & rel. nav. for swarms of UAVs:**
  - Sensor placement in small compartments, such as the shoe sole or small UAVs
  - Low power - compatible with energy harvesting & reduced weight of batteries
  - Wide temperature range & shock environment
  - Goals of navigation accuracy during walking of **1 m position error after 10 hours** and **size of 1 cc and power of 5 mW**, not including the IMU

APPROACH

- **Develop & Demonstrate Micro- and Nano-scale navigation sensors that use secondary inertial variables, e.g. relative velocity measurements (Radio Frequency, etc)**

- **Integrate and Demonstrate System: Nav sensors with MEMS Inertial Measurement Unit/Magnetometer using Zero Velocity Updates and Kalman Filter**

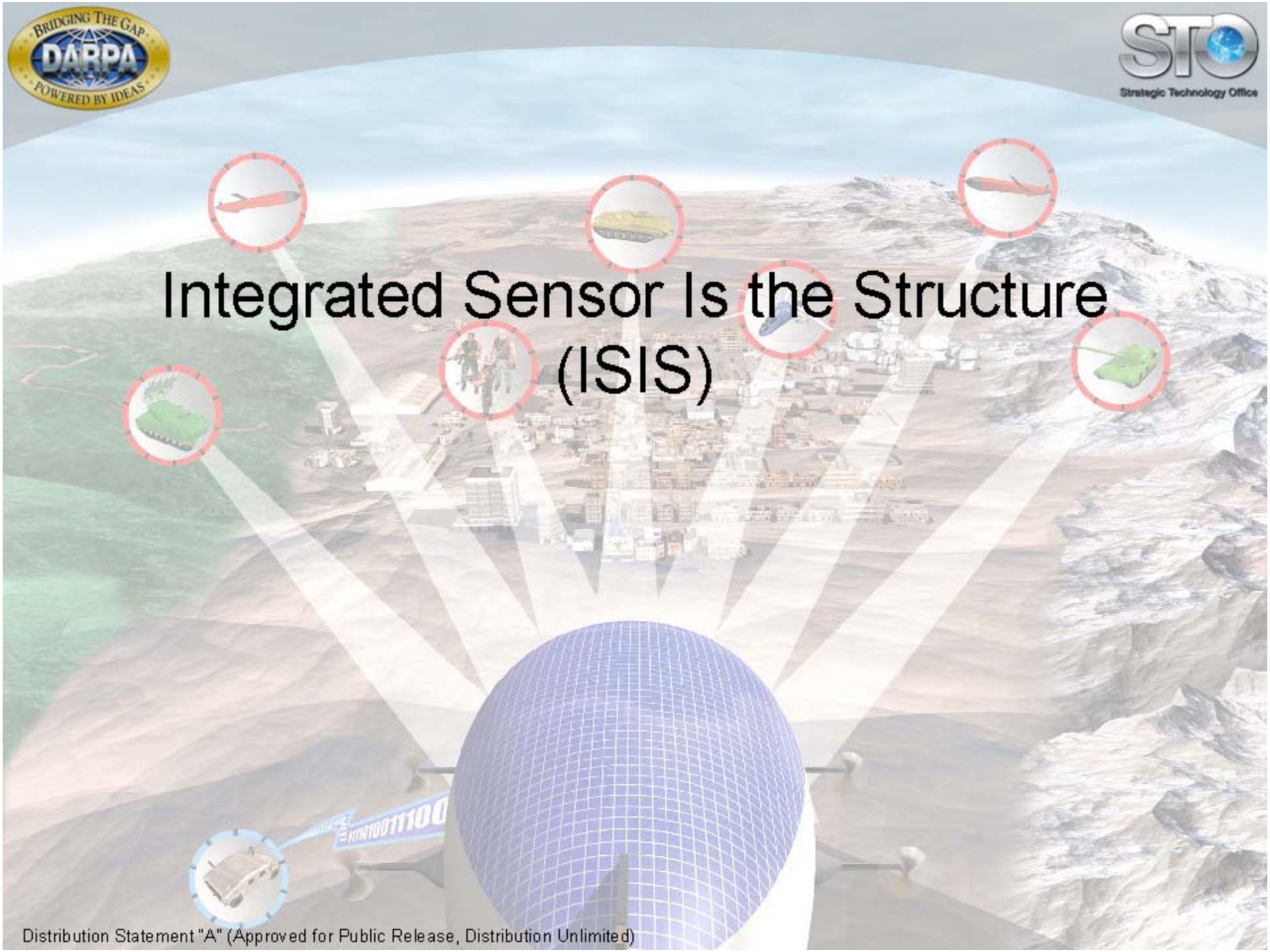
SMU1 DISTAR case # 13418

Stephen M Urban, 5/26/2009

Current DARPA Programs

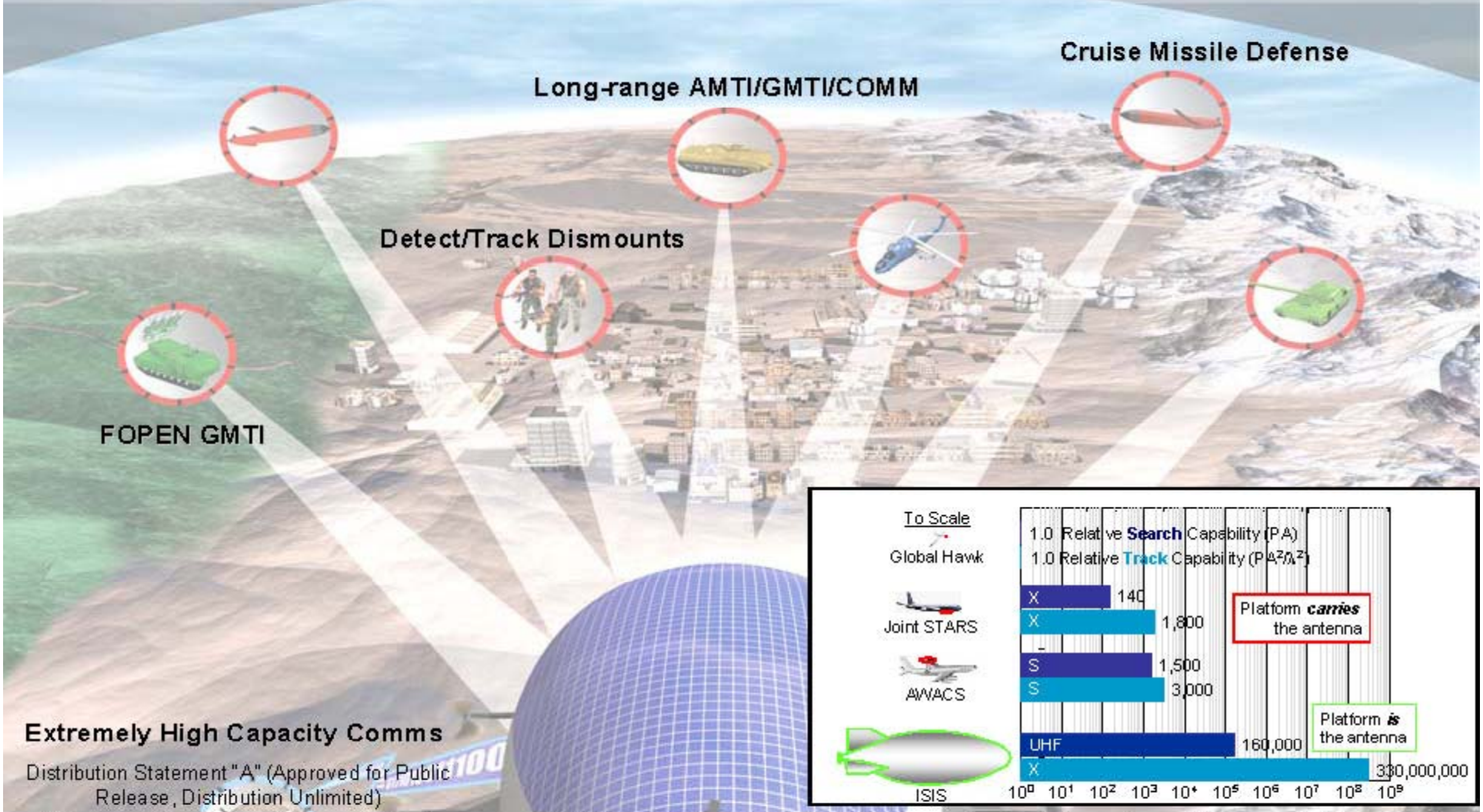
That support EUCOM/AFRICOM needs

- Long endurance, persistent surveillance
  - Integrated Sensor is the Structure (ISIS)
  - Vulture
  - Rapid Eye



Integrated Sensor Is the Structure (ISIS)

Simultaneous AMTI/GMTI Operation via Dual Band (UHF/X-Band) Aperture



Extremely High Capacity Comms

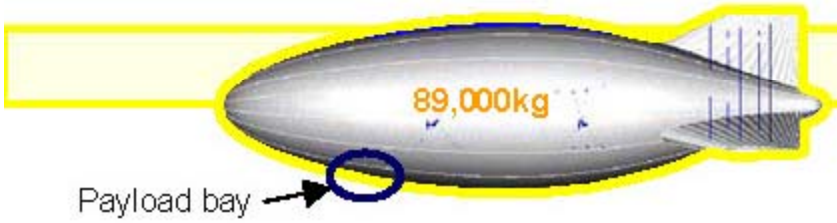
Global Relocation <10 days – 600km Sensor Radius – No In-Theater Ground Support

10+ year Operational Lifetime – 99% Availability for 1 year

Integrated Airship-Radar

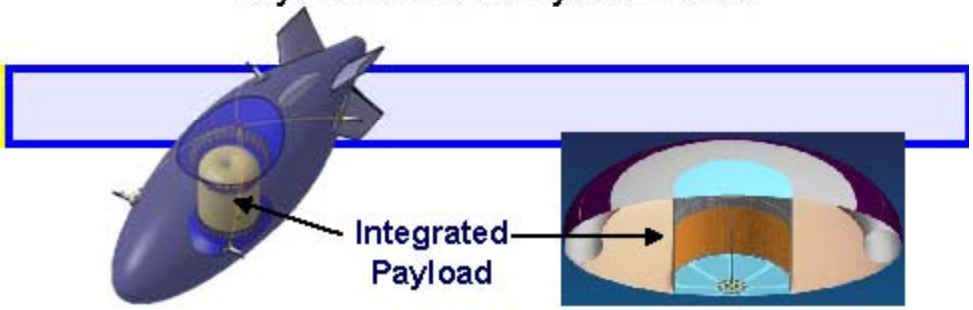
Conventional

Payload: 2-3% of system mass



ISIS New Paradigm

Payload: >30% of system mass

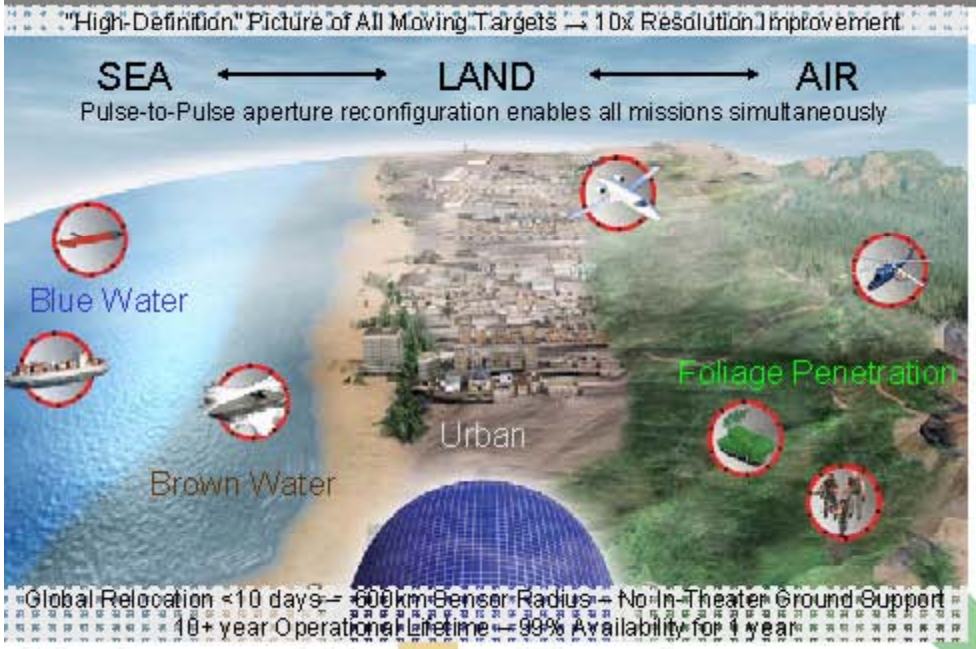


Enabling Technologies	DARPA ISIS Accomplishments
Hull Material	• Improved lifetime by 10x while reducing fabric mass 4x over state-of-the-art
Active-Array Antenna	• Performance from size, not power • Removed heavy high power electronics, cooling • Removed structure: Flexible panels bonded onto pressure vessel • Low-power Transmit/Receive modules based on low-cost "cell phone" technology
Power System	• Solar-regenerative power with fuel cells instead of batteries • Airspeed: 60 knot sustained, 100 knot sprint

ISIS Critical Technologies

Addressing critical hardware technology needs	Achieved	
• Low areal-density advanced hull material		Mass
– Areal density ≤100 g/m^2	90.6 g/m^2	
– Matrix glass transition temperature (T_G) ≤ -90°C	-101°C	
– Fiber strength-to-weight ≥ 1000 kN·m/kg	1274 kN-m/kg	
– Fiber retains >85% strength at 5 years	>85% at 22 years	
• Lightweight, low-power density AESA		
– Areal density ≤ 2 kg/m^2	1.8 kg/m^2	
– Power consumption ≤ 5.0 W/m^2 on receive	4.7 W/m^2	
– Bonded to hull material	Passed	
• Extremely low-power Transmit-Receive modules		Power
– FOM ≥1x10^4 W^{-2}	1.1 x 10^4 W^{-2}	
– Demonstrated TRL5 (MTTF >10^6 Hours)	MTTF >1.98x10^6 Hours	
• Novel power systems for stratospheric airships		
– Demonstrate 400 W-hr/kg regenerative system	779 W-hr/kg	

Single Integrated Picture

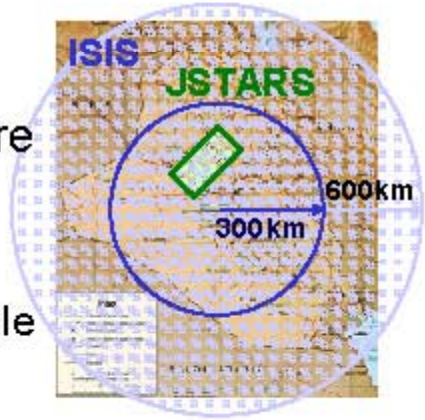


Complete Air Picture

- AWACS (70's) and E-2 (60's) – designed for hard targets of their day
- ISIS is designed for the theoretical limit at the radar horizon
  - Single-platform search, track, and fire-control

Unobscured Surface Target

- Joint STARS (70's) designed for tanks in the Fulda Gap
- ISIS is designed for dismounts across the entire Line-of-Sight
  - LSRS-like resolution
  - 300km @ 3° grazing angle
  - 600km line-of-sight



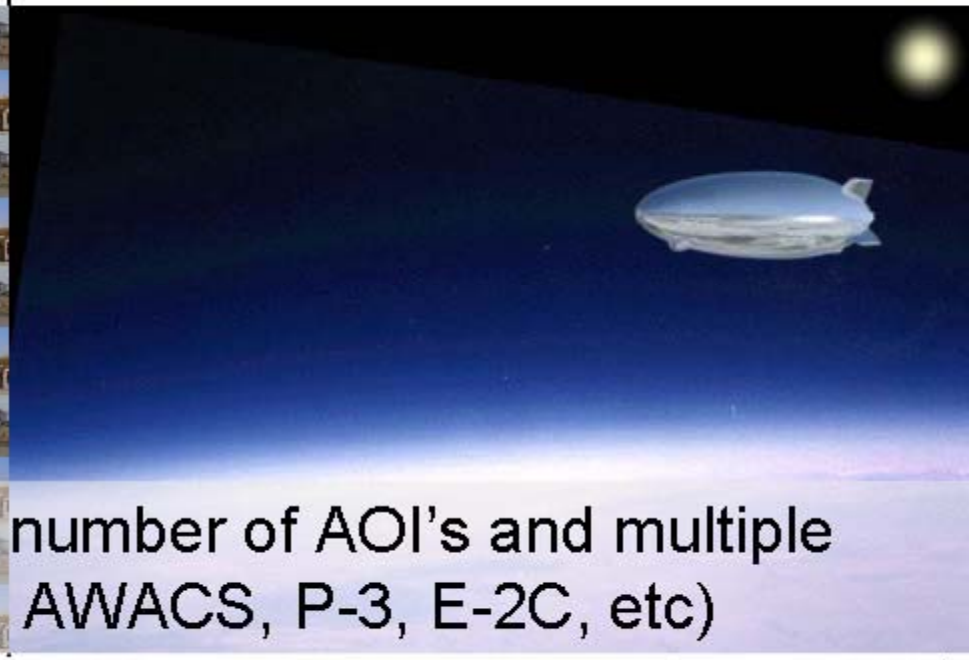
Wide-Area Foliage Penetration GMTI

- Joint STARS precision across an extremely large operational area

No Forward-Based Logistics

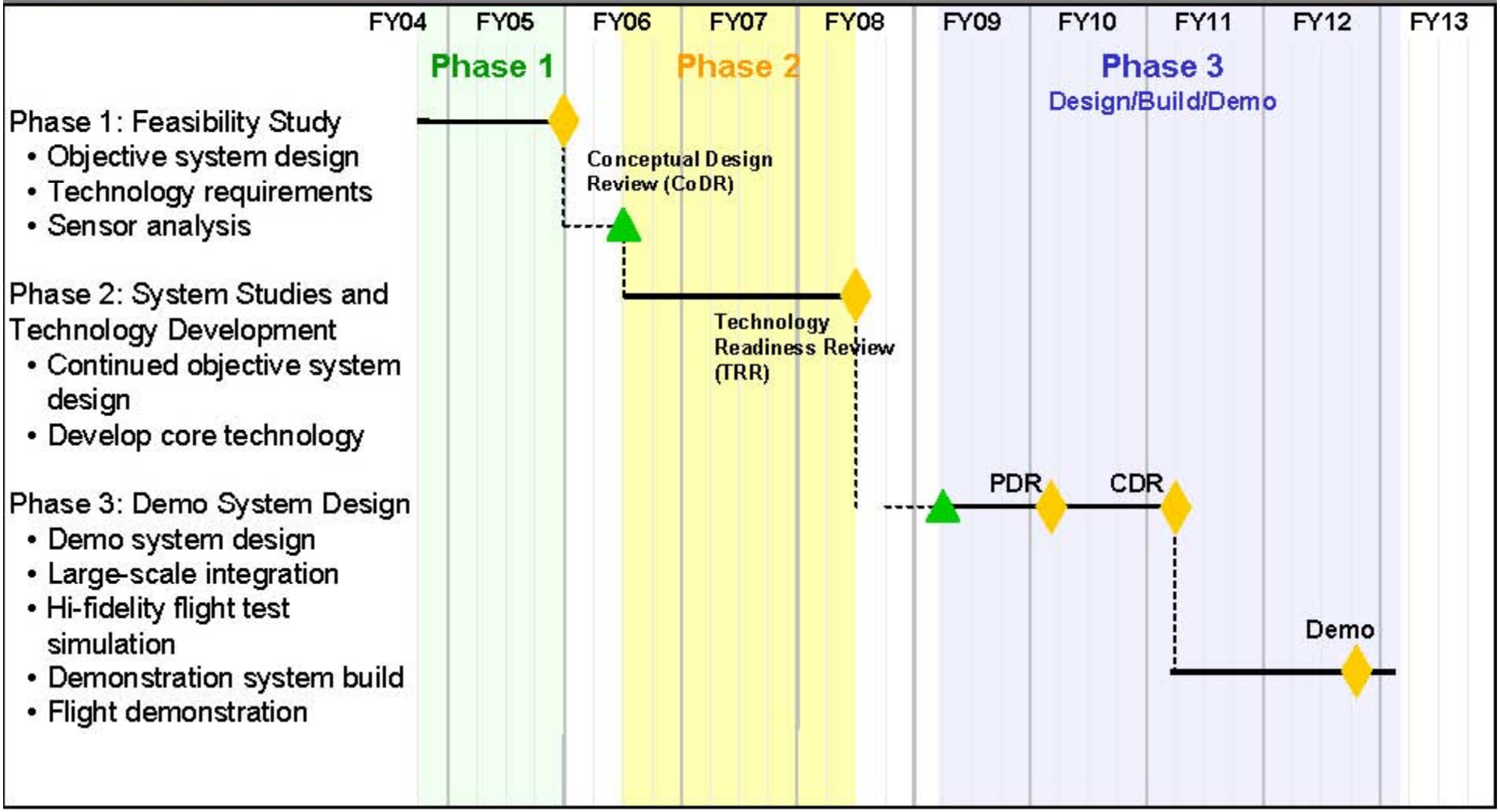
- Forward-deployed aircraft-based ISR
  - Local air base
  - Multiple aircraft for single orbit
  - Air crews
  - Ground crews
  - Fuel supplies
  - Maintenance facilities

- CONUS-deployed ISIS
  - Unmanned
  - Launched from U.S. locations
  - Global deployment in 10 days
  - Regenerative fuel sources
  - Ten-year service life
  - Permanent CONUS ground station



Multiply the cost delta by the number of AOI's and multiple platform types (JSTARS, AWACS, P-3, E-2C, etc)

Schedule


FY04
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Phase 1
Phase 2
Phase 3
Design/Build/Demo
Phase 1: Feasibility Study
• Objective system design
• Technology requirements
• Sensor analysis
Conceptual Design Review (CoDR)
Phase 2: System Studies and Technology Development
• Continued objective system design
• Develop core technology
Technology Readiness Review (TRR)
Phase 3: Demo System Design
• Demo system design
• Large-scale integration
• Hi-fidelity flight test simulation
• Demonstration system build
• Flight demonstration
PDR
CDR
Demo

VULTURE

Program Goals and Objectives

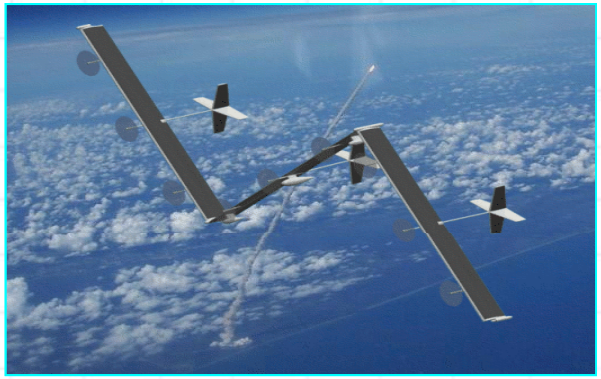
- Develop a high altitude, long endurance UAV that can maintain a 1000 lb, 5kW payload on-station continuously for 5 years

Technical Approach

- Satellite design paradigm with ultra reliability requirements
- Collecting, storing and dispersing solar electric energy
- High Lift/Drag (~40) – low mass fraction structures
- Efficient electric propulsion

Military Utility

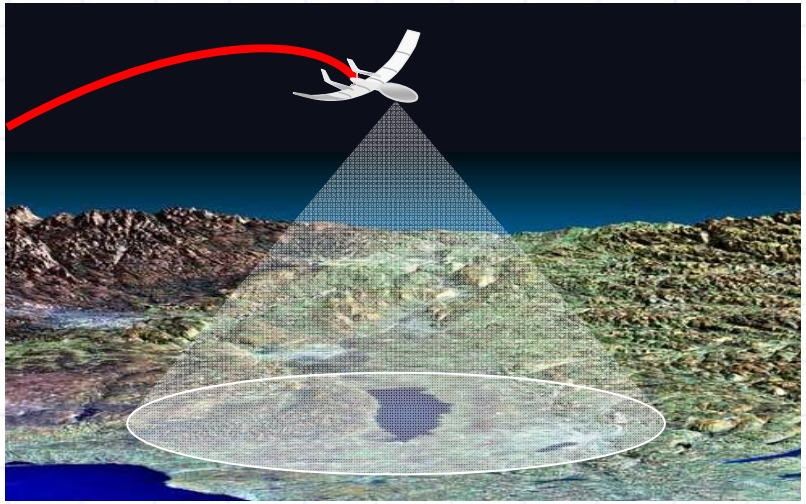
- 24 / 7 / 366 persistence
- Very high resolution capability without large aperture sensors needed from space
- Reduced power required in pseudo-satellite role
- Flexible re-tasking/responsiveness
- No depot or foreign basing
- 'Zero Maintenance foot print'
- Pre-deploy eliminates weather launch issues/reduces response time
- Decreased Cost and fleet size



Rapid Eye

Program Objective and Goals

- Develop and demonstrate the ability to deliver a persistent intelligence surveillance and reconnaissance (ISR) capability anywhere on the globe within 1-2 hours
- Program goals:
  - Worldwide-delivery of ISR capability from alert pad < 2 orbits (~ 2 hours using existing solid rocket)
  - Use only two START-compliant launch sites
  - Aircraft time-on-station > 7 hours
  - Aircraft payload > 500 lbs, 5 kW



Technical Approach

- Conduct military utility and system-level design trade studies, and derive a technology maturation plan to culminate in a system flight test demonstration

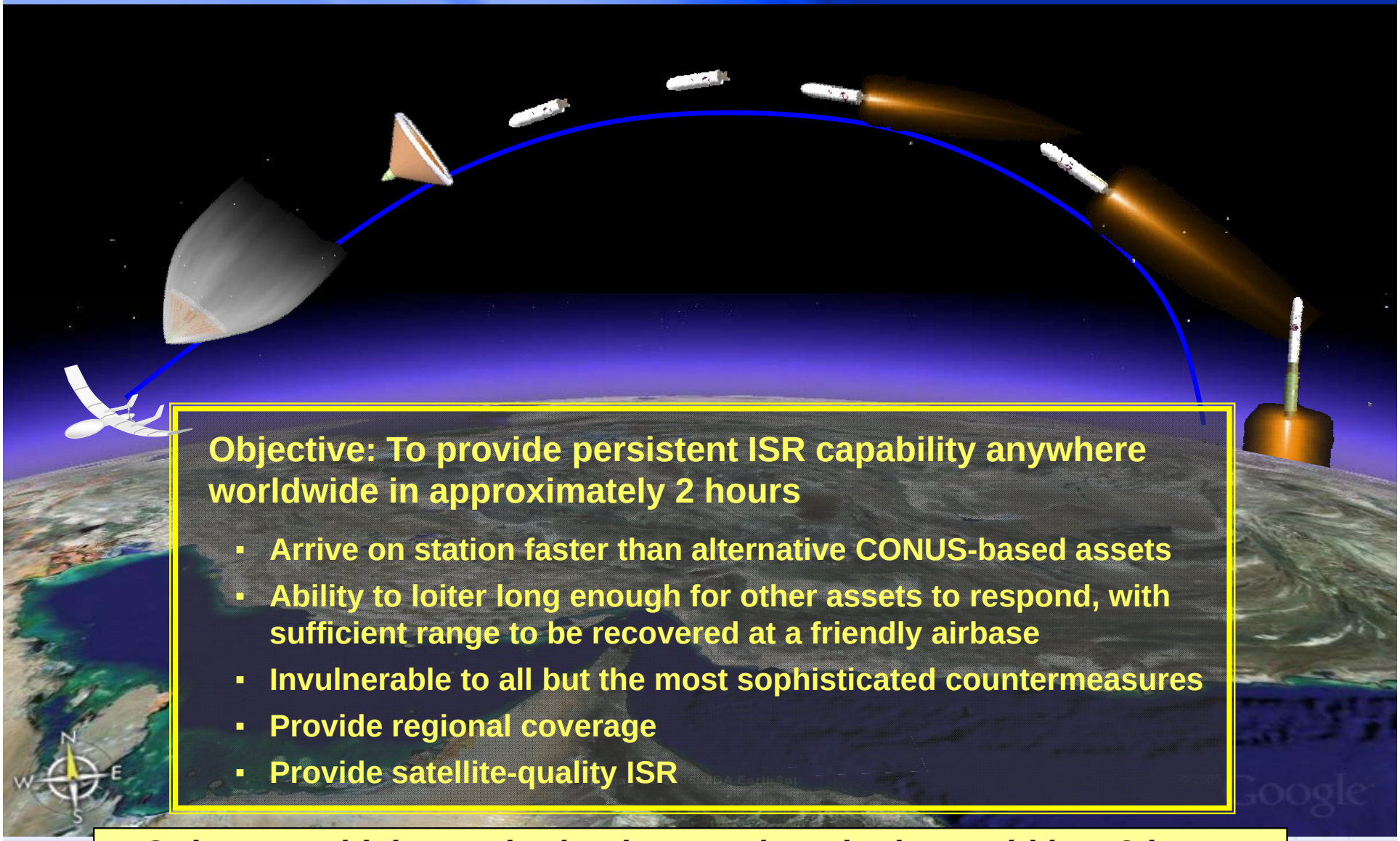
Technical Challenges

- Volume of stowed aircraft, deployable wings
- Deceleration at high altitude using inflatable aero-shield
- Propulsion suitable for >15 hrs at high altitude

Military Utility

- Provide an extremely rapid deployable ISR/C2 platform to surge capability until lower cost assets can be positioned
- Provide capability to enter denied airspace while avoiding border air defense

Rapid Eye
Bridging the ISR Deployment Gap



Objective: To provide persistent ISR capability anywhere worldwide in approximately 2 hours

- Arrive on station faster than alternative CONUS-based assets
- Ability to loiter long enough for other assets to respond, with sufficient range to be recovered at a friendly airbase
- Invulnerable to all but the most sophisticated countermeasures
- Provide regional coverage
- Provide satellite-quality ISR

Only one vehicle required to be anywhere in the world in ~ 2 hours

Current DARPA Programs

That support EUCOM/AFRICOM needs

- Networking/SA for Distributed Operations
  - UltraVis

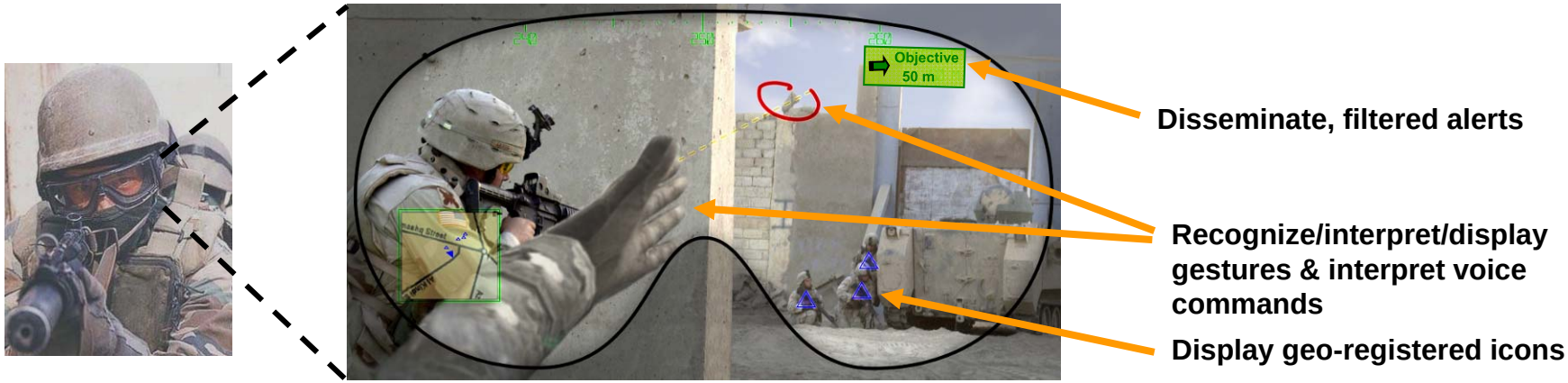
ULTRA-Vis
... A revolution in Small Unit C²

Problem: ***Small unit coordination inadequate to conduct NLOS, Distributed Operations***

- Communicate by shouting
- Operate within earshot and LOS
- Radios hard to hear
- Stop to use handheld CDAs

Solution: **Interpret/disseminate/display time-critical combat information**

- while looking ahead, hands on weapon, and on the move



Revolutionary approach to small unit C2 and Situational Awareness at the lowest echelon for hand-off of *actionable combat information*

ULTRA-Vis Program Gates

Phase 1: Critical Technology Demonstrations

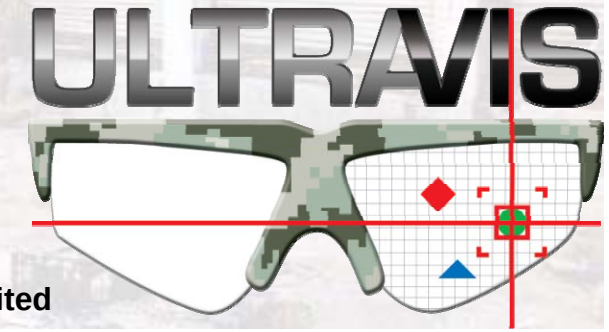
- Task a: Recognize hand and arm signals (gestures)
- Task b: Create/display geo-registered icons from different perspectives
- Task c: See icons in full sunlight conditions on see-through display
- Task d: Conduct system design trade study and CONOPS development

Phase 2: Multi-Modal Testbed Demonstrations

- Task a: Display icons in 3 colors (R-G-B)
- Task b: Integrate multi-modal testbeds for test and evaluation
- Task c: Support system test and evaluation

Phase 3: System Prototypes for Evaluation/Transition

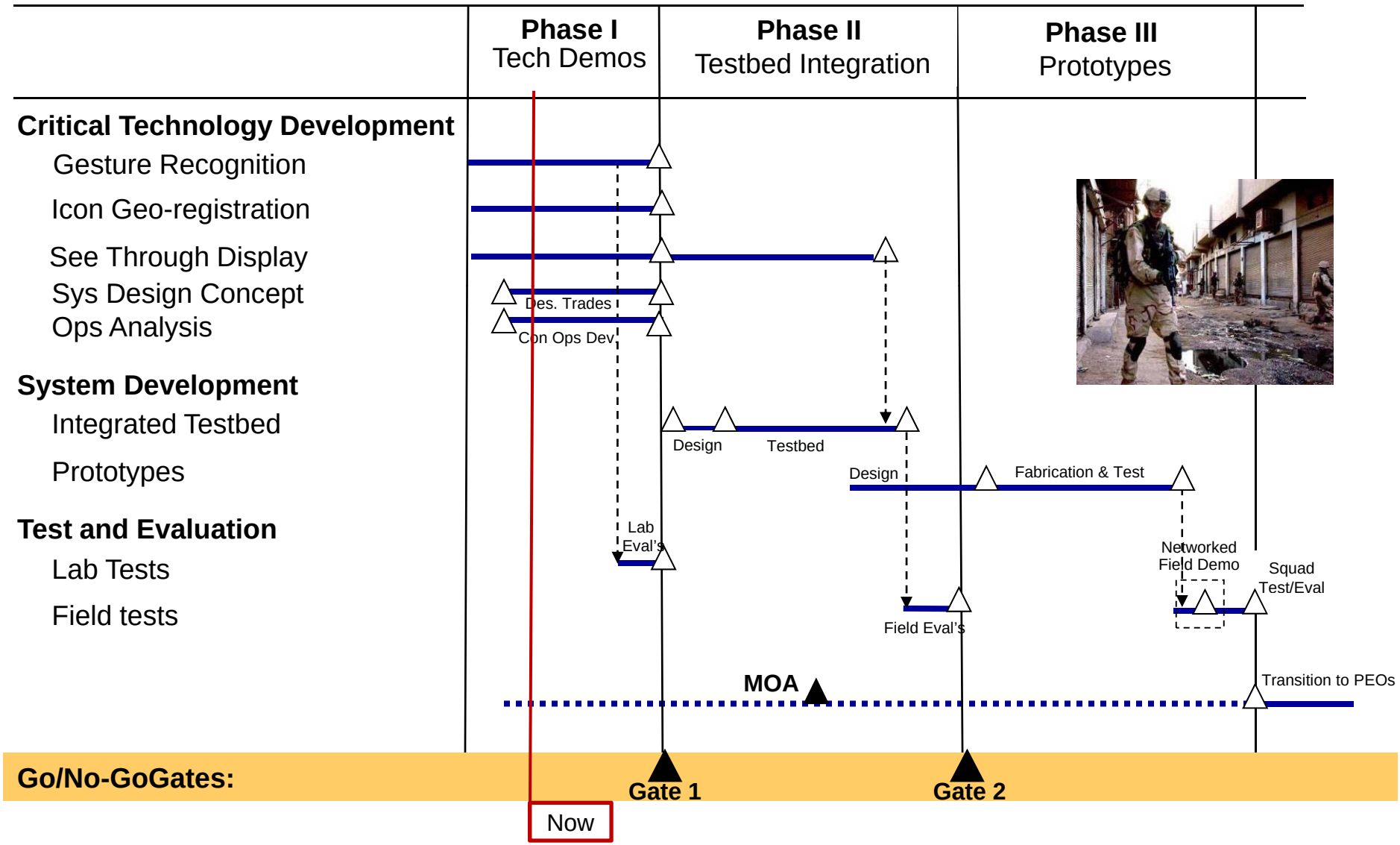
- Task a: Fabricate/test/demonstrate prototype units for transition
- Task b: Support Service field evaluation



ULTRA-Vis Gate Metrics

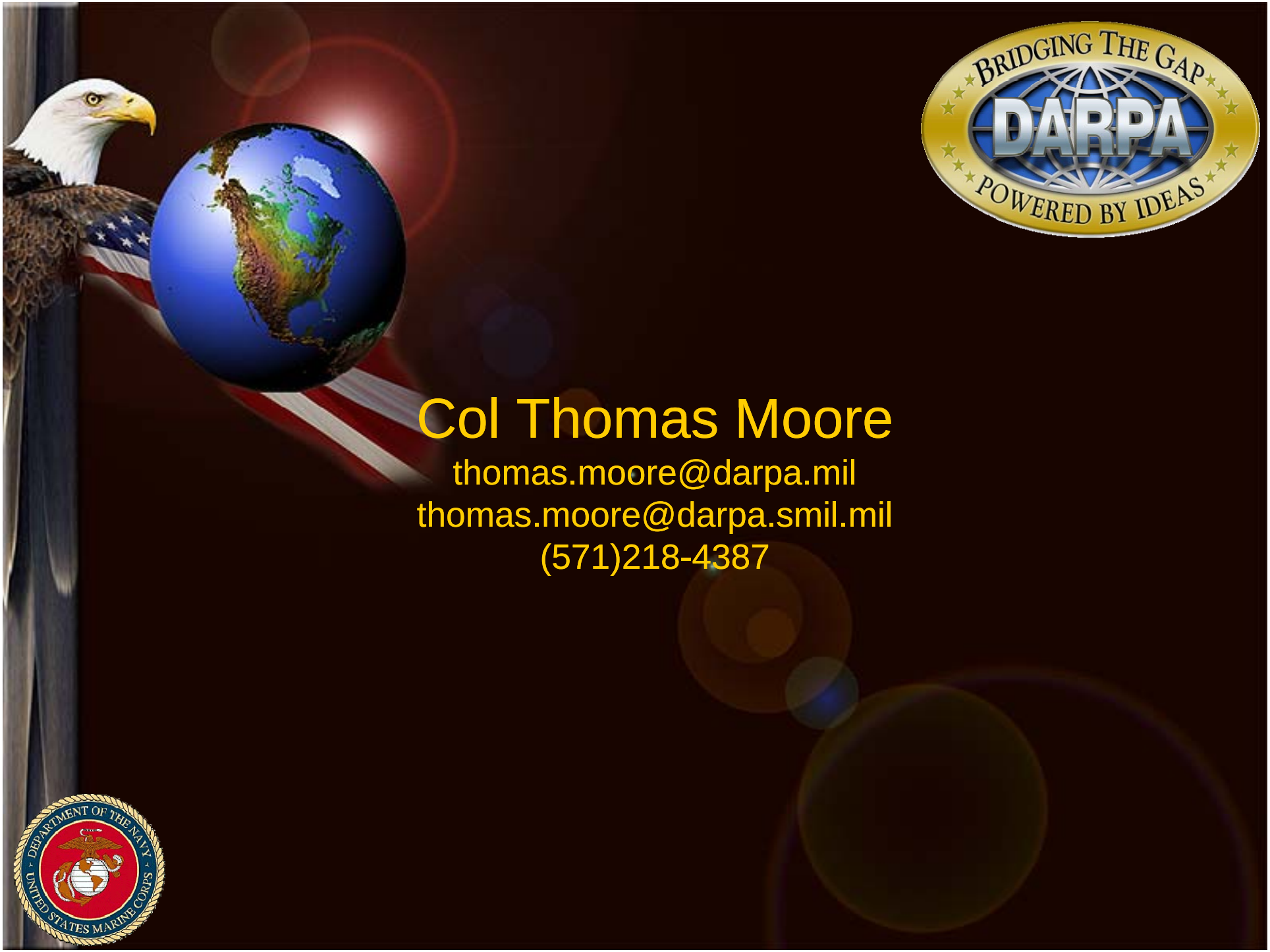
Phase	Gate Rqmt	Operational Metric	Go/No-Go Criteria
1	**Gesture Recognition**	Recognize Leader's Standard Hand & Arm Signals	> 99% probability of correct recognition of at least 10 hand & arm signals < 1% False Alarms
	Geo-Registered Icons	Create/display geo-registered icons from Leader's pointing action on two see-thru displays	Placement Accuracy: < 10 mrad, angular accuracy (1m @100 m) < 0.1 m, range accuracy < 0.5 mrad, jitter @ 60 Hz update
	See-Thru Display	See icons (monochrome) in full sunlight	≥2000 Ft-L brightness (monochrome) 40° FOV
2	**Integrated Multi-Modal Testbed**	Create/disseminate command information using two, networked, Soldier-worn Testbeds with: - Head-Mounted Display - Navigation units - Audio interface (mic/headset) - Voice/Data Radio - Hand/Arm gesture interface - Tactile Cueing device	3-color (R-G-B) icons, ≥2000 Ft-L, 40° FOV > 99% probability of correct recognition (sender) and representation (receiver) of multi-modal commands (hand/arm gestures + voice) < 1% False Alarms
3	**Prototypes**	Demonstrate system functionality with fifteen (15) prototypes for Transition	System weight (including battery): < 3 lbs System power: < 6 W

ULTRA-Vis Program Schedule



USMC SharePoint site

- *Info about unclas programs*
- *Collaborative site to interact with others in the USMC S&T community*
- *Calendar of upcoming events*
- *Weekly Activity Reports (WAR)*
- *Contact info for PM's*
- *To request access, send e-mail to: thomas.moore@darpa.mil or stephen.urban.ctr@darpa.mil*



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